AN EXPANDABLE BLADDER FOR TYRE MANUFACTURING APPARATUSES, A MANUFACTURING METHOD THEREOF AND A PROCESS FOR MANUFACTURING TYRES FOR VEHICLE WHEELS

Description

The present invention relates to an expandable bladder for tyre manufacturing apparatuses made up of two or more elastomer materials having different compositions, disposed in several mutually-coupled layers, for example.

It is also an object of the invention to provide a method of manufacturing said bladder.

In the embodiments that will be disclosed in the present description, the invention is conceived to be utilised within the scope of tyre manufacturing processes, and more particularly in the building steps of green tyres.

Building of tyres for vehicle wheels generally involves that a carcass sleeve be formed on a building drum, which carcass sleeve comprises one or more carcass plies wound up in a cylindrical conformation and two annular reinforcing structures fitted on the axially opposite end flaps of the carcass ply in coaxial relationship, in such a manner that said flaps axially project from the annular reinforcing structures themselves.

Also applied on the building drum is a pair of sidewalls of elastomer material extending each in the axial extension of one of the end flaps of the carcass ply.

An annular belt structure is made in a separated work station and a tread band can be subsequently associated therewith, at a radially external position. The annular belt structure together with the tread band possibly already applied thereto, are picked up by an annular transfer element to be disposed in coaxial relationship with the carcass sleeve disposed on a building drum, or possibly meanwhile transferred onto a shaping drum. Following axial approaching of two halves of the building or the shaping drum, and simultaneous injection of fluid into the carcass sleeve, the carcass ply is given a toroidal configuration so that it radially expands until it is brought into contact with the inner surface of the belt structure.

Before or after the above described conformation step, the sidewalls and/or end flaps of the carcass ply must be turned up around the annular reinforcing structures to be applied against the carcass ply. To this aim, it is usually provided that associated with the building or the shaping drum be at least one pair of bladders that are expandable between a rest condition at which they are substantially flattened against a cylindrical surface of the drum itself and a work condition at which they are inflated to reach a substantially toroidal conformation.

In the rest condition, the bladders supply a support seat to which the sidewalls and/or end flaps of the carcass ply are applied. During inflation, the bladders lift the sidewalls and/or the carcass ply so as to turn them up around the annular reinforcing structures and apply them against the carcass ply. In particular applications, such as manufacture of tyres for motorcycles, use of expandable bladders may also be

provided in order to facilitate a correct application of the belt structure and the possible tread band to the carcass structure. More particularly, it is for this purpose provided that at least two expandable bladders be associated with the annular transfer device used for supporting the belt structure in coaxial relationship with the carcass sleeve; said bladders are located at axially opposite positions and can be activated for bringing the axially opposite edges of the belt structure and the possible tread band towards the carcass ply shaped in a toroidal conformation. Thus correct application of the belt structure is ensured over the whole width, even on carcass structures having a cross-section profile with a strong curvature.

The expandable bladders of the mentioned type, usually made of elastomer material such selected as to promote the duration features and the reduced manufacturing costs of the bladders themselves, can call for the presence of reinforcing inserts, usually of the textile or metallic type, to control the geometric deformations of said bladders during inflation. In addition, particular expedients are required to be adopted so that the sticky nature of the raw elastomer material constituting the different construction elements of the tyre does not hinder a regular separation of the bladder from the tyre under working, when the bladder itself is brought back to the rest condition.

To face up to this requirement, resorting to surface treatments is known, said treatments essentially consisting in setting suitable adhesiveness-preventing substances or cross-linking agents, usually applied by spraying, onto the outer bladder surfaces.

These treatments however involve different problems, originating from the material used as cross-linking or adhesiveness-preventing agent, the necessary equipment and the required time for carrying out the treatment. The surface treatment can also give rise to problems in terms of environmental impact, because the materials used as cross-linking or adhesiveness-preventing/release agents can be dangerous.

The Applicant has further found that use of these substances, even when handled with great precaution, can cause an undesirable pollution of the raw elastomer materials constituting the tyre components, thereby impairing the physical and mechanical-strength features of the finished product.

Associating inserts of butyl material or latex foam with the bladder in the parts designed to get into contact with the tyre components is also known; however, these materials do not always offer sufficient assurances as regards their remaining firmly bonded to the bladder itself.

The state of the art proposes different solutions for reducing adhesion of a bladder to the tyre surfaces. For instance, document JP 63125311 proposes manufacture of an expandable bladder to be used for tyre curing, by means of an elastomer composition comprising an organic rubber and a poly-organo-siloxane containing a specific silicone-modified elastomer as the solubilizing agent.

In document JP 5031724 use of an expandable layered bladder is proposed for tyre curing, which has an inner elastomer layer consisting of butyl rubber and an outer elastomer layer consisting of silicone rubber. The

inner layer of butyl rubber ensures a hermetic seal to the steam under pressure, whereas the outer layer of silicone rubber facilitates sliding of the bladder on the inner tyre surfaces and release therefrom when vulcanisation is over.

The Applicant however has found that in manufacturing bladders of this type several difficulties are encountered for obtaining an efficient and reliable union between the inner and outer layers because they are made of different elastomer materials. In particular, the butyl and silicone polymeric bases are not very compatible with each other because they are not able to carry out cross-linking together, i.e. to form stable molecular bonds with each other, which impairs reliability and duration of the layered bladders made in accordance with the known art.

The Applicant has perceived that for obtaining a process advantageously using a layered bladder it is necessary to provide an efficient attachment means between non compatible blends like the butyl one and silicone one, in order to avoid the above mentioned problems.

The Applicant has found that manufacturing the different layers of said bladder in such a manner as to obtain a mechanical engagement between the contacting surfaces makes it possible to obtain bladders made of non-compatible blends that are very reliable and of long duration for use in combination with a tyre-manufacturing apparatus, because the forces tending to separate the different layers as a result both of the inflating pressure and of the forces transmitted to the workpiece, are counteracted by the constraining

reactions generated between the contact surfaces of the different layers as a result of said mechanical engagement.

More specifically, in accordance with the present invention, the different materials required in manufacturing a layered bladder are arranged in the form of a continuous elongated element and mutually coupled before or during winding of same on a forming support, so as to obtain a layered coating in which the materials are mutually joined according to an undulated interface profile defining complementary elements of mechanical engagement between the materials themselves. By suitably selecting the shape and mutual arrangement of the elongated elements, the conformation of the undulated interface profile can be controlled with a wide margin, for example as regards the wave width and pitch, so as to increase the coupling surface between the materials.

It is therefore an object of the invention to provide an expandable bladder for tyre manufacturing apparatuses, as defined in claim 1.

It is a further object of the invention to provide a method of manufacturing said bladder, as defined in claim 14.

The invention also proposes new processes and apparatuses for tyre manufacture, as defined in claims 39 and 43, respectively.

Further features and advantages will become more apparent from the detailed description of a preferred but not exclusive embodiment of an expandable bladder

for tyre manufacturing apparatuses, of the related manufacturing method, as well as of the processes and apparatuses for manufacturing tyres for vehicle wheels in accordance with the present invention.

This description will be set out hereinafter with reference to the accompanying drawings, given by way of non-limiting example, in which:

- Fig. 1 diagrammatically shows, in a fragmentary diametrical section, a manufacturing apparatus incorporating expandable bladders in accordance with the invention, during the inflating step;
- Fig. 2 is a fragmentary cross-section view of the bladder in Fig. 1 to an enlarged scale;
- Fig. 3 laterally shows a diagram of the simultaneous laying of a first and a second elongated elements on a forming support, for the purpose of manufacturing the expandable bladder in reference;
- Fig. 3a laterally shows a diagram of the simultaneous laying of a first and a second elongated elements on a forming support, in accordance with a possible alternative embodiment;
- Fig. 3b laterally shows a diagram of the simultaneous laying of a first and a second elongated elements on a forming support, in accordance with a further alternative embodiment;
- Fig. 4 diagrammatically shows a continuous strip-like element in cross section, to be obtained from mutual coupling between the first and second elongated elements, close to the plane along line IV-IV in Fig. 3 for example;
- Fig. 5 shows, by way of example, a deposition diagram of the continuous strip-like element in the form of coils disposed close to each other to obtain an expandable bladder as shown in Fig. 2;

- Fig. 6 diagrammatically shows a continuous strip-like element in cross-section to be obtained by coupling a first and a second elongated elements in a triangular conformation, according to a possible alternative embodiment of the invention;
- Fig. 7 is a fragmentary section view of a deposition diagram of the continuous strip-like element shown in Fig. 6, in the form of coils disposed close to each other.

With reference to the drawings, an expandable bladder for tyre-manufacturing apparatuses in accordance with the present invention has been generally identified by reference numeral 1.

In the embodiment shown in Fig. 1, at least one pair of bladders 1 is used in combination with a manufacturing apparatus generally identified with 2, comprising a building or a shaping drum 3 on which a carcass structure 4 is formed which comprises at least one carcass ply 5, a pair of annular reinforcing structures 6 in engagement with the opposite end flaps 5a of the ply itself, at the tyre areas usually identified as "beads", and a pair of sidewalls 7 of elastomer material extending away from the annular reinforcing structures 6.

The building or shaping drum 3 consists of two halves 3a, 3b that can be mutually approached to cause the carcass structure 4, initially disposed in the form of a cylindrical sleeve on the drum itself, to be shaped into a toroidal conformation in order to apply a radially external portion of the ply 5 against the inner surface of a belt structure 28, possibly coupled with a tread band 29 and retained to a position coaxial

with the carcass sleeve by an annular transfer device 30.

In the example in Fig. 1 a first pair of bladders 1 is in engagement, each by respective anchoring tailpieces 1a formed close to the circumferential edges thereof, with the respective halves of the building or the shaping drum 3. Fluid-admitting devices (not shown) usually associated with drum 3 supply air or other fluid under pressure to the inside of each bladder 1 to cause inflation of the latter starting from a rest or deflated condition shown in solid line, to a work condition shown in chain line. In the rest condition, bladder 1 is substantially flattened against drum 3 to provide a cylindrical support surface for the respective sidewall 7 and/or the end flap 5a of the carcass ply 5. In the work condition, bladder 1 on the contrary, takes a substantially toroidal conformation to cause turning up of the end flap 5a around the respective annular anchoring structure 6, and/or application of the sidewall 7 against the side surface of the carcass ply 5, after the latter has been shaped into a toroidal configuration.

In the example shown in Fig. 1 the manufacturing apparatus 1 is particularly adapted to the manufacture of tyres the profile of which has a high curvature as in the case of tyres for two-wheeled vehicles and is provided, in addition to or in place of the above described bladders with reference to the building or the shaping drum 3, with a second pair of expandable bladders 1 carried by the annular transfer device 30, each of them being close to one of the axially opposite edges of the device itself. In the rest condition, each of the bladders 1 is flattened against an inner

cylindrical surface of the annular transfer device 10, as shown in chain line, whereas in the work condition each bladder is radially expanded towards the inside of the device itself, taking a substantially toroidal conformation. In the work condition each bladder 1 acts close to the axially opposite edges of the belt structure 28 and the possible tread band 29, so as to cause application of the latter against the carcass structure 4 already having a toroidal conformation, to enable coupling with the belt structure itself.

When manufacture has been completed, the tyre is usually submitted to a moulding and vulcanisation step.

Each expandable bladder 1 is advantageously made up of at least one first layer 8 of a first elastomer material, and one second layer 9 of a second elastomer material different from the first elastomer material and placed at a radially external position with respect to the first layer 8. The first and second layers 8, 9 are advantageously coupled at an undulated interface profile 10 defining mechanical-engagement elements 10a between the first and second layers 8, 9.

In a preferential embodiment, the first elastomer material forming layer 8 placed at a radially internal position consists of a natural or synthetic rubber-based blend (a butyl-based blend, for example) or mixtures thereof, so as to surely give the expandable bladder 1 good features of duration, resistance to stresses and reduced manufacturing costs.

The second elastomer material forming the second layer 9 in turn preferably consists of a silicone-based blend or a blend of other material that is little compatible

with the blends used for tyre manufacture, so as to promote release of bladder 1 from the sidewall 7 or other structural tyre component submitted to the action of the bladder itself, when the latter is brought from the operating condition back to the rest condition.

As shown in Fig. 1, the first layer 8 can advantageously extend over the whole extension of the respective bladder 1, whereas the second layer 9 preferably extends following a surface portion of the first layer 8, located in the vicinity of one of the circumferential edges of the bladder itself, limitedly to the areas designed to get into contact with the sidewalls 7 or other tyre components.

As shown in Fig. 2, a wave pitch P and a wave height H can be identified in the undulated interface profile 10. In the present specification and in the following claims by wave "pitch" of the interface profile it is intended the distance P measured in an axial direction in right section between the median points of two consecutive waves. In the context of the present definition, the median point of each wave is the mean point of segment "n" joining the opposite radially inner ends of said wave. In Fig. 2 the line Z on which value P is indicated is parallel to the geometric axis of bladder 1 and therefore represents the axial direction. The radial direction E is indicated herein and in the following of the specification and the appended claims, at right angles to line Z.

Finally, in the present description and in the following claims by "height" of each wave of said interface profile it is intended projection H on a plane parallel to the equatorial plane of bladder 1

(that in the example shown is coincident with the radial direction E), of a segment "m" extending in a right-section plane perpendicularly to segment "n" joining said radially inner wave ends, or to the extension of the segment itself, between said segment or the segment extension and the radially outermost point of the wave.

To enable an efficient mechanical engagement between layers 8 and 9, the wave height H is preferably equal to or higher than one tenth of, and preferably higher than half the wave pitch P, so as to obtain effective mechanical-engagement elements 10a also in the absence of undercuts.

In the embodiment shown in Fig. 2, the wave height H is as high as about two times the value of the wave pitch P.

In addition and advantageously, the waves defining the undulated profile 10 may be provided to have an extension, identified by the bisecting line K of the vertex of each wave, inclined to a direction Q normal to a median line L of the extension of the undulated profile itself, even to a greater extent than shown in Fig. 2. More specifically, in accordance with a preferred embodiment, to provide a particular mechanical engagement, the inclination angle α included between said bisecting line K and the perpendicular Q to the median line L is included between about 45° and about 88°, and more preferably between about 60° and about 85°.

A suitable value of the inclination angle α, among other things, allows an efficient coupling between the

first and second layers to be ensured even when the layered component of which they are part is very restricted.

In addition or as an alternative to the above description, the complementary mechanical-engagement elements 10a defined by the interface profile 10 may be provided to have portions 10b of mutual undercut constraint, as shown in Fig. 7.

As viewed from Figs. 5 and 7, a third layer of elastomer material 11 may be further provided, said layer being disposed at a radially internal position to the first layer 8 and being co-crosslinked with the elastomer material forming the first layer.

If required, a fourth layer of elastomer material 12 may be also arranged at a position radially external to the second layer 9, said fourth layer being cross-linked with the elastomer material belonging to at least the second layer itself.

In a preferential technical solution, the bladder has an overall thickness S included, by way of indication, between 1 and 8 mm, equal to about 2 mm for example. The radially internal portion of bladder 1 formed of the first layer 8 and the possible third layer 11 preferably has a thickness, measured with reference to said median line L of the undulated interface profile 10, greater than 1/2, and preferably corresponding to at least 3/5, of the overall thickness S of the bladder.

The thickness of the radially external portion of bladder 1, made up of the second layer 9 and the fourth

layer 12, if any, will be advantageously reduced to no more than half the overall thickness S, to the benefit of the bladder manufacturing costs, since the blend of natural or synthetic rubber or blends thereof is less expensive than the silicone-based blend and is also more durable due to its greater mechanical strength.

Manufacture of the expandable bladder 1 described above contemplates preparation of a first elongated element 13 and a second elongated element 14 made of the first and second raw elastomer materials, respectively. The first and second elongated elements, obtained by extrusion and fed from a first 15 and a second 16 extruder respectively, are guided to at least one roller 17 or other feeding member that lay them down on a deposition surface 18a of a forming support 18 of a cylindrical shape or other suitable shape depending on the geometrical features of the expandable bladder to be obtained. The forming support 18 is preferably supported by a robotized arm 19 only partly shown as it is already known from document WO 00/35666 A1 in the name of the same Applicant. The robotized arm 19 gives the forming support 18 a circumferential-distribution rotatory motion around the geometric rotation axis X thereof, by effect of which a circumferential distribution of the elongated elements 13, 14 laid by the feeding roller 17 on the deposition surface 18a is caused.

Simultaneously, the robotized arm 19 moves the forming support 18 in front of the feeding roller 17 through controlled relative displacements of transverse distribution, so that the first and second elongated elements 13, 14 laid on the deposition surface 18a are formed into coils wound around the geometric axis X of

the forming support 18.

On coming out of the respective extruders 15, 16, the first and second elongated elements 13, 14 are guided in mutually converging directions towards a point of mutual coupling in which the elongated elements themselves meet and adhere to each other forming a continuous strip-like element 20 that is laid and distributed on the forming support 18 as above described.

In the example in Fig. 3, the coupling point of the elongated elements 13, 14 is coincident with the application of same to the forming support 18 by the feeding roller 17. However said elongated elements 13, 14 can be also guided in such a manner as to cause coupling of the latter at a point upstream of the forming support 18. It may be also provided that the continuous strip-like element 20 should come from a supply reel, used in a storage step of the strip-like element itself after carrying out mutual coupling of the elongated elements 13, 14.

In a further alternative embodiment, the elongated elements 13, 14 can be co-extruded and directly coupled in the extrusion head of a single extruder 26 (Fig. 3a) so that the strip-like element 20 is directly generated at the extruder exit.

Finally, in a different embodiment shown by way of example in Fig. 3b, the elongated elements 13, 14 can be simultaneously laid on the forming support 18 at points A, B that are mutually spaced apart in a circumferential direction. In this instance, the coupling point between the elongated elements is

coincident with the application point of the second elongated element 14 onto the forming support 18.

As can be viewed from Figs. 4 and 6, the elongated elements 13, 14 are mutually coupled in such a manner that, when coupling has occurred, each of them has a base portion 21, 22 in contact with the base portion of the other elongated element. In addition, at least one of the elongated elements 13, 14 may have an apex 23, 24 projecting from the base portion 21, 22, in a direction transverse to the direction of mutual alignment of the base portions themselves, denoted at D in said figures.

In more detail, in a preferential embodiment the elongated elements 13, 14 that can have a conformation substantially identical with each other, are coupled at mutually offset positions in a plane transverse to the mutual alignment direction D of the base portions 21, 22, so that each of them has a respective apex 23, 24 projecting in the opposite direction with respect to the apex of the other elongated element.

During laying on the forming support 18, mutual positioning of the elongated elements 13, 14 and/or orientation of the continuous strip-like element 20 formed by them is controlled in such a manner that, on coming close to the deposition surface 18a, the apex 23 of the first elongated element 13 is turned towards the forming support 18.

As can be clearly seen looking at Figs. 5 and 7, apex 23 of the first elongated element 13 of butyl material, during application is deformed and it consequently bends towards the base portion 22 of the second

elongated element 14, taking an interposed position between the second elongated element 14 and the forming support 18 so as to avoid a direct contact of the second elastomer material against the deposition surface 18a. At the deposition surface 18a, the coils disposed consecutively in side by side relationship and formed by the first elongated element 13, by effect of bending of apex 23 as above described, give rise to a continuous layer of butyl material extending over the whole deposition surface 18a.

Apex 24 of the second elongated element 14, in turn, is oriented radially away from the deposition surface 18a exhibited by the forming support 18 and can be turned up against the base portion 21 of the first elongated element 13, so that the coils in side by side relationship formed by the second elongated element 14 cause formation of a continuous layer of silicone material.

If required, turning up of apex 24 of the second elongated element 14 can be assisted by a roller or other auxiliary applicator member 25, operating downstream of the feeding roller 17.

Following deposition in the form of coils in side by side relationship, in addition, the base portions 21, 22 of the first and second elongated elements 13, 14 generate the interface profile 10 between the first and second layers.

If required, application of the first and second elongated elements 13, 14 can be preceded by application of the third layer 11 of a blend consisting of natural or synthetic rubber or a mixture thereof,

in any case susceptible of cross-linking with the first elastomer material forming the first elongated element 13. Formation of this third layer can take place in the same manner as previously described with reference to laying of the continuous strip-like element 20, i.e. through application of a continuous elongated element of elastomer material, coming from an extruder for example and formed into coils disposed consecutively in side by side relationship to cover the deposition surface 18a of the forming support 18.

Subsequently to laying of the first and second elongated elements 13, 14, application of the above mentioned fourth layer 12 may be also carried out, said layer being made of a silicone material or at all events a material suitable for cross-linking with the second elastomer material forming the second elongated element 14. Formation of the fourth layer 12 too can be carried out by applying onto the forming support 18, a fourth elongated element of elastomer material coming from an extruder and formed into coils disposed consecutively in side by side relationship. The third and fourth elongated elements 11, 12 can be advantageously produced either by the same extruders 15, 16 used for formation of the first and second elongated elements 13, 14, or by specific extruders dedicated thereto.

In the presence of the third and/or fourth elastomer layers 11, 12, arrangement of apices 23, 24 projecting from the first and second elongated elements 13, 14 respectively may appear to be superfluous, as said third and fourth layers can be cross-linked with the material forming the base portions 21, 22 of the elongated elements 13, 14, respectively.

As shown in Fig. 5, the elongated elements 13, 14 can have a conformation with a substantially flattened cross-section. In this case an interface profile 10 as shown in Fig. 2 is preferably obtained, in which the wave height H is greatly higher than the wave pitch, so that the hills and valleys of the undulated profile will cause formation of the mechanical-engagement elements. Alternatively, as exemplified in Figs. 6 and 7, the elongated elements 13, 14 can advantageously have a cross-section profile of triangular conformation. In this case the base portions 21, 22 of the coupled elongated elements 13, 14 give rise to formation of portions 10b with an undercut constraint, in the mechanical-engagement elements 10a. The same effect is achieved using elongated elements 13, 14 having a trapezoidal cross-section profile.

When formation of layers 8, 9, 11, 12 on the forming support 18 has been completed, the expandable bladder 1 lends itself to be introduced into a mould to be submitted to a moulding and vulcanisation step that can be carried out in any convenient manner. During this step, in the same mould as used for moulding and vulcanisation of the bladder it is possible to inject elastomer material for causing formation of said third and/or fourth layers 11, 12 and/or of any other additional coating layer.

The present invention achieves important advantages.

In fact, any problem resulting from the difficulty of joining a silicone blend to a natural or synthetic rubber-based blend or a mixture thereof in a steady and reliable manner can be brilliantly overcome so as to manufacture a very durable and reliable expandable

bladder that eliminates the necessity to carry out surface treatments in order to promote release or separation of said bladder from the tyre components.

In addition, the bladder in reference lends itself to be made in a simple and cheap manner, utilising machinery and equipment already provided in modern tyre-production cycles in which the elastomer components are obtained by winding up elongated elements of raw elastomer material in the form of coils disposed in side by side relationship on a forming support, as described in document WO 00/35666 A1 in the name of the same Applicant.